(12) UK Patent Application (19) GB (11) 2 239 056 (13) A

(43) Date of A publication 19.06.1991

(21) Application No 8923996.6

(22) Date of filing 25.10.1989

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(51) INT CL⁵
F02C 9/26

(52) UK CL (Edition K)
F1G GCB GNB G807 G819 G821

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(58) Field of search
UK CL (Edition K) F1G GCB GNB GNX
INT CL⁵ F02C

(54) Selective fuel supply to gas turbine engine fuel injectors

(57) In order to reduce atmosphere pollution at low power settings, such as during idle power/taxi modes, fuel is supplied to only a limited number of the fuel injectors 21 during that low power operation. Control means 25 responds to signals from a sensor, which are indicative of steady state idling conditions after start up of the engine, and is operable to actuate shut off valves 24, 24A, ... in the fuel supply 22, 22A to fuel injection systems of selected combustion chambers 17 of the engine. All injectors may be used for start-up, acceleration, and high power operation with fuel being supplied to less than half the fuel injectors during idling. The injectors may be shut off in sequence.

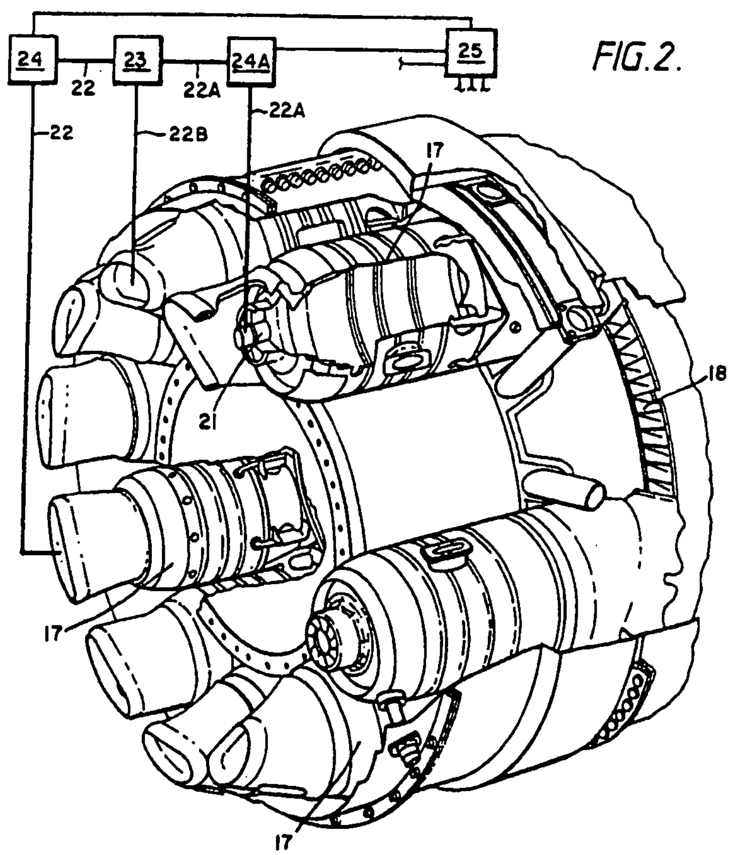

FIG.2.

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.
The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1990.

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FIG. 1.

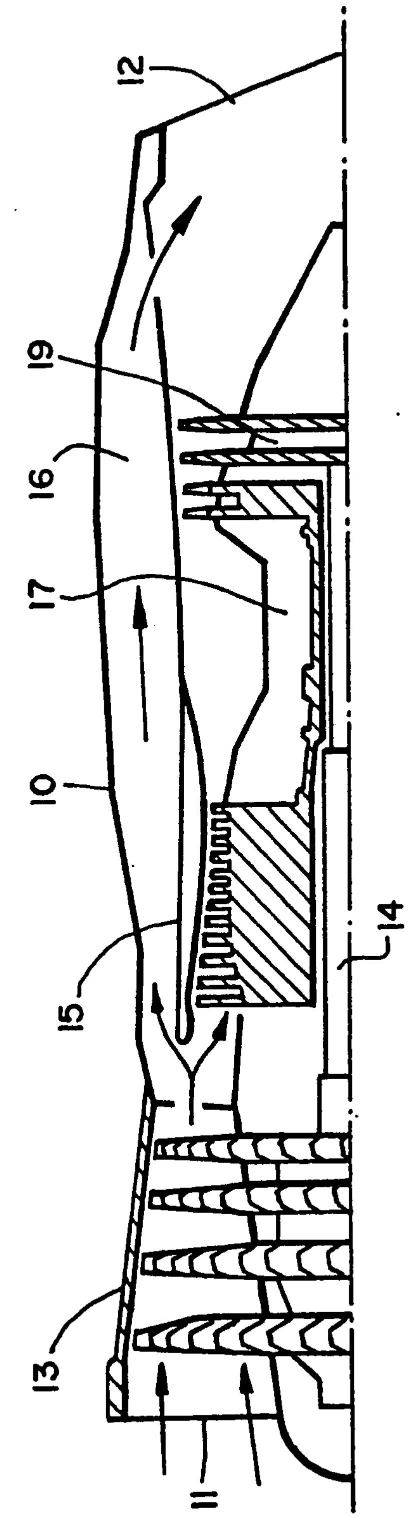
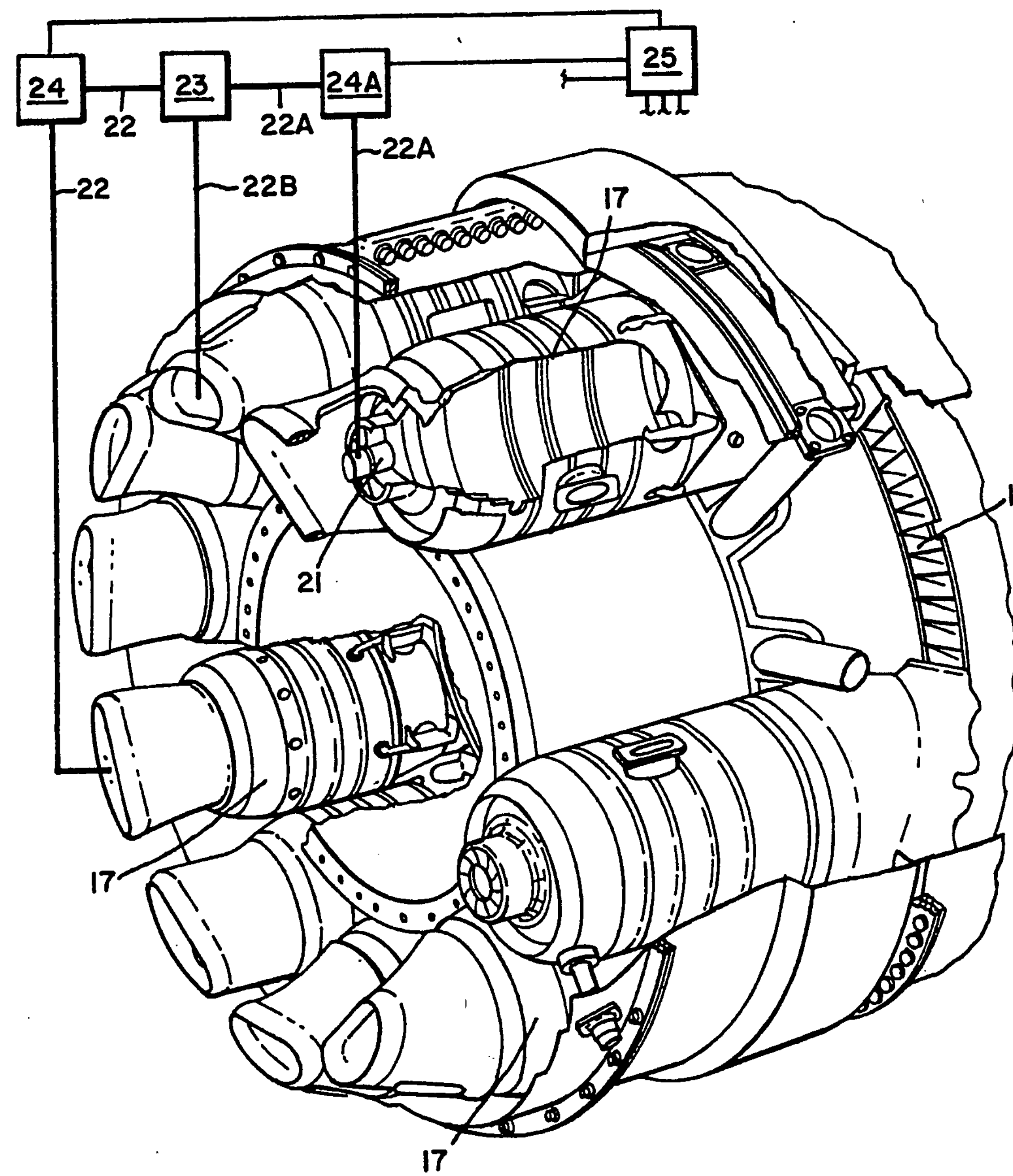


FIG.2.



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DESCRIPTION

GAS TURBINE ENGINES

This invention relates to gas turbine engines and more particularly to reduction in pollution by operation of gas turbine engines.

Aircraft are major contributors to atmospheric pollution at and around airports.

The exhaust emissions cycle for callibrating aero-engine emission is weighted towards the taxi-out and taxi-in mode and 26 minutes of operating in the 7% rated thrust mode is the criteria used in the evaluation. In comparison, the 100% take-off power emissions are computed for only 0.7 minutes and the emissions during climb are considered for only 2.2 minutes at 85% rated thrust.

There are several configurations of gas turbine engines. Combustion chamber arrangements commonly used are either annular or comprise an array of circumferentially-spaced separate combustion chambers within the combustion section, each combustion chamber

of the array being tubular in form and having its own fuel injection arrangement. The latter kind of combustion chamber arrangement is known as a tubo-annular combustion system.

Gas turbine engine combustion systems are obviously working dramatically below optimum conditions during the idle power/taxi modes and as a result insufficient oxidation of the hydrocarbon fuel occurs. Similar problems arise during idling operation of gas turbine engines in marine installations or in fixed land-based installations.

Broadly, in accordance with this invention, in order to reduce atmospheric pollution in the operation of a gas turbine engine at low power settings, fuel is supplied to only a limited number of the fuel injectors of the engine during the low power ground operating mode of the engine. The tubo-annular combustion system is preferable for the application of this invention. In practice, while fuel would be supplied to all the injectors of the engine for start-up, acceleration and high power operation of the engine, it would be supplied to probably less than

half of the fuel injectors of the engine during the idling mode. This may be achieved by shutting off the supply of fuel to selected fuel injectors, conveniently in sequence, once the engine has been started up and steady state idling conditions have been established.

According to a feature of the invention, a gas turbine engine having a tubo-annular combustion system is provided with means which are indicative of the establishment of steady state idling conditions after start-up of the engine and which are operable to actuate shut-off valves in the fuel supply to the fuel injection systems of selected combustion chambers of the engine so as to shut-off the supply of fuel to those injection systems when such steady state idling conditions are established. Preferably said means include sequencing means whereby the shut-off valves are actuated one after another so that the supply of fuel to the respective injectors is shut-off in sequence. In practice all the shut-off valves are normally open so that they can supply fuel to the engine under all circumstances when the invention is not in operation. The selected combustion chambers to

be deprived of fuel by operation of the invention may be evenly-spaced around the engine.

One embodiment of this invention will be described now by way of example with reference to the accompanying drawings, of which:-

Figure 1 is a diagrammatic half cross-section of a gas turbine engine of the by-pass type with a tubo-annular combustion system; and

Figure 2 is a perspective view of the tubo-annular combustion system of the engine shown in Figure 1.

Figure 1 shows the engine comprises an annular casing 10 having an inlet 11 at one end and an outlet 12 at its other end. There is a low pressure compressor 13 adjacent the inlet 11. The compressor 13 comprises a plurality of axially-spaced arrays of radially extending axial flow blades mounted at axially-spaced intervals on a shaft 14, the blades extending to a location adjacent the casing 10 and being of a progressively smaller outside diameter the further they are from the inlet 11.

Journaled for rotation substantially coaxially around the shaft 14 on the side of the blades of the low pressure compressor 13 downstream of the inlet 11, is a high pressure compressor 15 which comprises a plurality of axially-spaced radially extending axial flow blades which extend to a smaller radius than the blades of the low pressure compressor 13, but which are also of a progressively smaller outside diameter the further they are from the inlet 11.

An annular space 16 is formed between the casing 10 and the high pressure compressor 15 as well as between the other components of the engine located between the high pressure compressor 15 and the outlet 12.

Extending axially from the end of the high pressure compressor 15 remote from the inlet 11, there is an array of combustion chambers 17 arranged at circumferentially-spaced locations around the shaft 14 to receive compressed air which emerges from the high pressure compressor 15. Figure 2 shows that the ends of the array of combustion chambers 17 from which hot combustion gases emerge are directed at a ring 18 of nozzle guide vanes and Figure 1 shows the air is

directed by those guide vanes onto the blades of a power turbine 19. The output from the power turbine 19 merges with a bypass airflow through the annular space 16 and is emitted through the outlet 12.

Figure 2 shows each combustion chamber 17 has a fuel spray nozzle head 21 mounted centrally at its end that is adjacent to the high pressure compressor 15. The fuel supply line 22, 22A, ..., from a common fuel supply 23 to certain of the combustion chambers 17 includes a respective shut-off valve 24, 24A, ... Each shut-off valve 24, 24A, ..., is controlled by signals emitted by a central controller 25 which is operable to emit a signal to each of the shut-off valves 24, 24A, ..., when activated to do so by operation of a sensor which is operable to indicate establishment of steady state idling conditions.

The combustion chambers 17 to which supply of fuel is controlled by a respective shut-off valve 24, 24A, ..., are evenly spaced around the axis of the tubo annular combustion system. They are at least half the total number of combustion chambers 17.

In operation of the invention, when the engine is started, fuel is supplied to all fuel injectors located in the nozzle heads 21, all the shut-off valves 24, 24A, ..., being open. That is because the fuel supply required to establish initial engine light-up is critical. Once steady state idling speed conditions are established, which will be indicated by the sensor, the central controller 25 will emit an activating signal to each of the shut-off valves 24, 24A, ..., in turn so that they are closed in sequence thereby shutting off the supply of fuel to the respective fuel injectors located in the spray nozzle heads 21 in turn. The supply of fuel to the remaining injectors located in the fuel spray nozzle heads 21 would be increased in order to maintain the required thrust rating for taxiing/idling purposes so that the combustion in their respective combustion chambers 17 would be at a higher power rating and therefore would be closer to the optimum combustion conditions which lead to a reduction in the unburnt hydrocarbons and carbon monoxide polutants exhausted.

Under these conditions, the combustion chambers 17 to which the supply of fuel has been shut-off would be doing nothing other than bypassing relatively hot air from the high pressure compressor 15 which could assist further oxidation of any remaining hot carbon monoxide and unburnt hydrocarbons during passage through the remainder of the engine downstream of the combustion chambers 17.

As the shut-off valves 24, 24A, ..., are normally open, fuel will be supplied to all the injectors located in the spray nozzle heads 21 in the event of failure of the control system which is thus fail safe. Other means to ensure the shut-off valves 24, 24A, ..., are in the open position for higher power operation, as well as in the event of failure of the control system, will be incorporated.

Systems will be incorporated which terminate the operation of the fuel shut-off valves 24, 24A, ..., prior to take-off and which reactivate the shut-off valve control system after landing.

CLAIMS

1. A method of operating a tubo-annular gas turbine engine at low power settings wherein fuel is supplied to only a limited number of the fuel injectors of the engine during the low power ground operating mode of the engine.

2. A method as claimed in claim 1, wherein fuel is supplied to all the injectors of the engine for start-up, acceleration and high power operation of the engine, but wherein fuel is supplied to less than half of the fuel injectors of the engine during the idling mode.

3. A method as claimed in claim 1 or claim 2, wherein the supply of fuel is shut off to selected fuel injectors once the engine has been started up and steady state idling conditions have been established.

4. A method as claimed in claim 3, wherein the fuel is shut off to the selected fuel injectors in sequence.

5. A gas turbine engine having a tubo-annular combustion system provided with means which are indicative of the establishment of steady state idling conditions after start-up of the engine and which are operable to actuate shut-off valves in the fuel supply to the fuel injection systems of selected combustion chambers of the engine so as to shut-off the supply of fuel to those injection systems when such steady state idling conditions are established.

6. A gas turbine engine as claimed in claim 5, wherein said means include sequencing means whereby the shut-off valves are actuated one after another so that the supply of fuel to the respective injectors is shut-off in sequence.

7. A gas turbine engine as claimed in claim 5 or claim 6, wherein the selected combustion chambers be deprived of fuel are evenly-spaced around the engine.

8. A method of operating a tubo-annular gas turbine engine at low power settings substantially as

hereinbefore described and with reference to Figures 1 and 2 of the drawings.

9. A gas turbine engine substantially as hereinbefore described and with reference to and as shown in Figures 1 and 2 of the drawings.

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